ABSTRACT

The turbulent slot impinging jet has many engineering and industrial applications due to the presence of very high rate of convective heat and mass transfer. The presence of strong streamline curvature, recirculation, boundary layer makes the flow very complex. The impingement plate motion makes the flow more complex by introducing the strong shear regions in the domain. The thesis starts with a brief introduction and literature survey relevant to the study followed by mathematical formulation. An in-house computer code is developed to study the flow field and conjugate heat transfer in a turbulent slot jet impinging normally on an impingement plate of finite thickness, the impingement plate being at rest or in motion. Subsequent chapter includes results of mean flow and turbulence characteristics. A parametric study involving the effect of nozzle-to-plate distance, Prandtl number, thermal conductivity ratio and impingement plate thickness on interface temperature, bottom surface temperature, local Nusselt number and local heat flux has been done. The interface temperature and the bottom surface temperature attained minimum values in the stagnation region where the local Nusselt number and local heat flux are maximum indicating a high heat removal rate. The Nusselt number is found to remain unaffected by the thermal conductivity ratio and impingement plate thickness. In order to find a suitable turbulence model to predict the fluid flow and thermal field in a turbulent slot impinging jet, the performance of RANS based turbulence models viz. the standard $k-\epsilon$ model, the Launder-Sharma (LS) and Yang-Shih (YS) versions of LRN $k-\epsilon$ model and the standard $k-\omega$ model have been tested. The obtained results were compared with standard experimental results on wall pressure, free jet mean velocity, spanwise velocity profiles, velocity fluctuation, skin friction coefficient, nondimensional velocity and temperature profiles in wall coordinates. The YS model is found to perform the best. The effect of impingement plate motion on the flow field and the conjugate heat transfer has been studied using the YS model. A thorough study of flow characteristics and heat transfer in fluid as well as in solid for different surface-to-jet velocity ratios has been carried out. It was found that the impingement plate motion exerts a drag force on the fluid resulting in skewed flow and temperature fields.

Key words: impinging jet; turbulent flow; numerical simulation; high Reynolds number; low Reynolds number; conjugate heat transfer; RANS